Thermally-Enhanced Extraction (TEE)

US Air Force Research Laboratory, Tyndall Air Force Base, Florida

The Need

The treatment of chlorinated solvent-contaminated groundwater is a multifaceted problem. The use of soil vapor extraction (SVE) alone lacks the ability to remove higher boiling point dense non-aqueous-phase liquids (DNAPLs) without thermal desorption and is not applicable to the saturated zone. Biological treatment systems can span long timeframes and may or may not have high DNAPL removal efficiency. Excavation, incineration, and landfill disposal of ash are costly and may require additional remediation measures to prevent leaching to aquifers. Application of groundwater pumping alone is also inefficient for removal of DNAPL globules trapped in saturated soils.

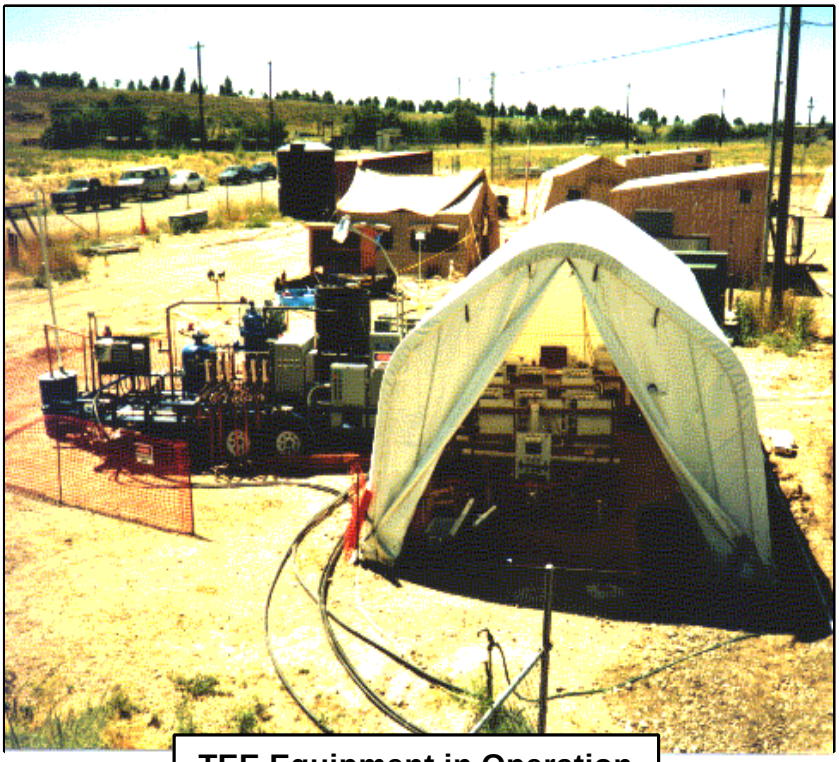
The Objectives

AFRL/MLQ, in conjunction with a Phase II Small Business Innovative Research (SBIR) project, field-demonstrated an in situ steam-enhanced extraction system by partial treatment of a trichloroethylene (TCE) plume at Operable Unit 2 (OU-2), Hill Air Force Base (AFB), Utah. The contaminant source at OU-2 is a prior chemical disposal pit, containing primarily TCE at 40 to 50 feet below ground surface.

The Technology

The in situ thermally-enhanced extraction (TEE) process is designed to remove volatile and semi-volatile organic compounds from an area of contaminated soil without the need for excavation. The process operates through the use of wells constructed in contaminated soil and groundwater. High-quality steam is introduced to the subsurface through injection wells. Extraction wells are operated under vacuum to remove liquid and vapor contaminants and water. The injection of steam into the ground raises the temperature of the soil and groundwater and causes the most volatile compounds to vaporize. A pressure gradient is formed between the injection and extraction wells, driving the flow of steam and vaporized contaminants towards the extraction wells. Raising the temperature of the subsurface also assists in the removal of less volatile compounds by increasing their in situ vapor pressure.

After the entire treatment area has reached the steam temperature, as determined by in situ monitors, and steam breakthrough occurs at the extraction wells, the flow of steam continues intermittently with a constant vacuum applied to the extraction wells. The vacuum extraction removes much of the remaining contamination. As the high-permeability region cools, the steam remaining in the low-permeability region evaporates the contaminant.



TEE Equipment in Operation

Demonstration Status

Full characterization of OU-2 was completed during the SBIR Phase I investigation. During early 1997, installation of injection, extraction, and monitoring wells was completed. The TEE demonstration was operated April through August 1997. Vapor treatment was accomplished using a two-stage condensation system. This was selected for its ability to treat high concentrations of chlorinated volatile organic compounds and freon found at OU-2. The demonstration resulted in greater than 90% removal efficiency for the target contaminants. The Environmental Protection Agency (EPA) Superfund Innovative Technology Evaluation (SITE) Program contributed pre- and post-demonstration Quality Assurance and Quality Control sampling and analysis. The public was invited to observe the TEE technology demonstration during a Visitor's Day sponsored by EPA SITE and Hill AFB in July 97.

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